NAVIGANT

ENERGY

CPUC Embedded Energy in Water Studies

Study 1: "Statewide and Regional Water-Energy Relationship Study"

Study 2: "Water Agency and Function Component Study and Embedded Energy-Water Load Profiles"

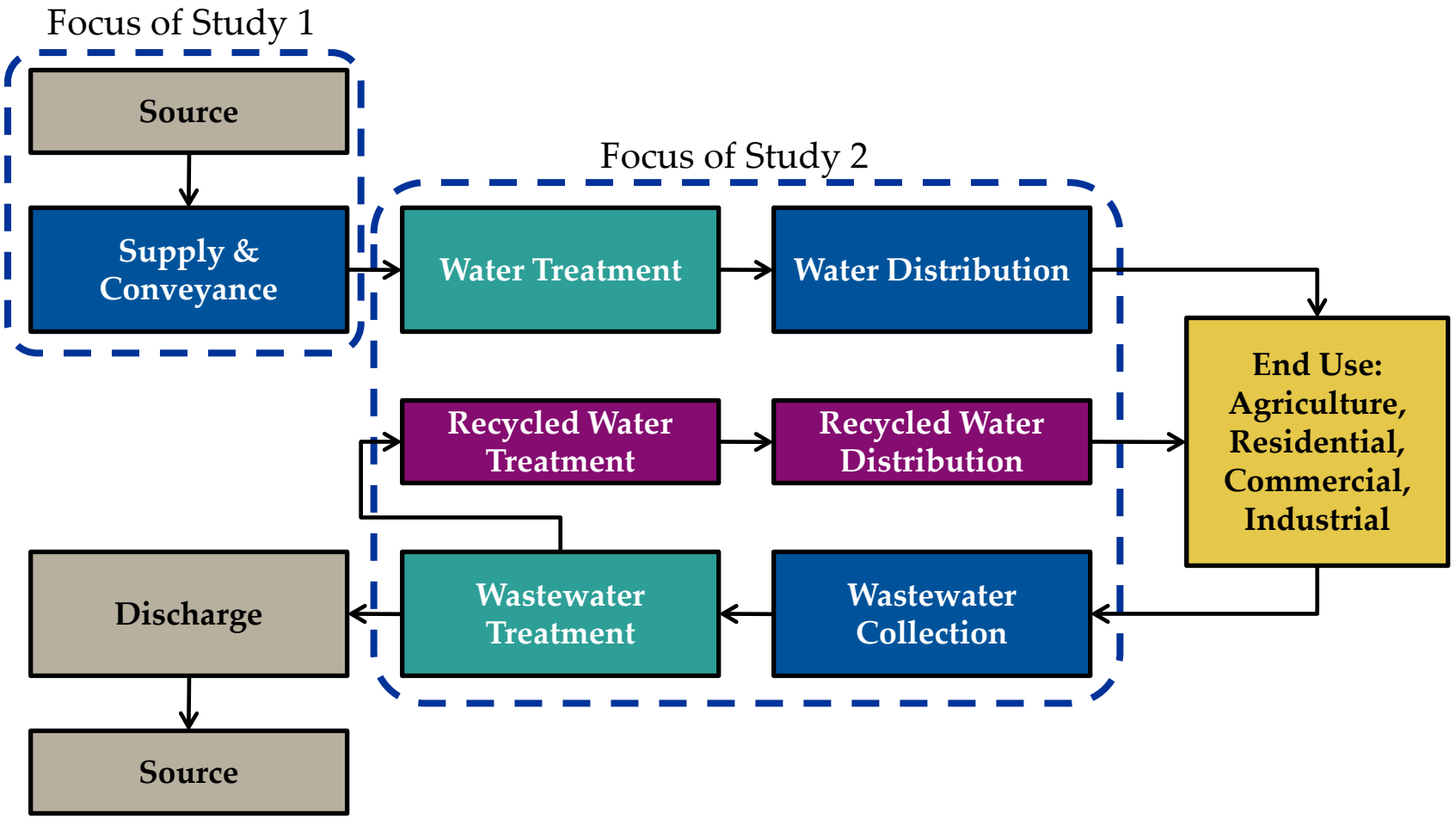
March 20th, 2013

Table of Contents

In 2007, the CPUC opened a proceeding to consider if/how energy embedded in water should be recognized as an energy efficiency resource.

- **Decision 12-07-050:**
  - Authorized the California Investor Owned Utilities (IOUs) to conduct water-energy pilots
  - Directed that three studies be conducted:
    - Study 1 - Statewide and Regional Water Energy Relationship Study
    - Study 2 - Water Agency and Function Component Study and Embedded Energy -Water Load Profiles
    - Study 3 - End-Use Water Demand Profile Study
- The CPUC engaged the California Institute for Energy and Environment (CIEE) to manage the three studies. The team of GEI Consultants, Inc. and Navigant Consulting, Inc. (the Study Team) was engaged to conduct Study 1 and Study 2.
- Both studies collected and analyzed significant amounts of water and energy data:
  - 10 years worth of water and energy data for nine large wholesale suppliers
  - One year of detailed monthly/hourly data for 20+ retail water agencies throughout California
  - Secondary analysis of additional water supplies (groundwater, recycled water, desalination, local surface water)

The two studies looked at different parts of the water system.



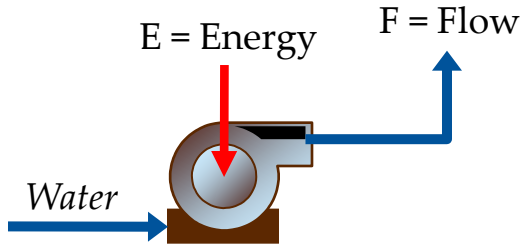
NAVIGANT ENERGY

Energy Intensity and Embedded Energy are two terms that are key to understanding the Water-Energy nexus

» **Energy Intensity (EI)**
- The average amount of energy needed to transport or treat water or wastewater on a per unit basis (kilowatt hours per acre-foot of water [kWh/AF]).
- The energy intensity is associated with a particular facility and is similar to a measure of efficiency.
- The energy intensities of individual facilities within a water agency can be aggregated to represent the energy intensity of water supply.

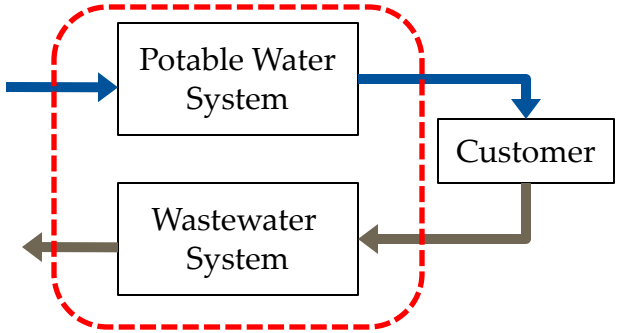
» **Energy Embedded in Water**
- The amount of energy that is used to collect, convey, treat, and distribute water to end users, and the amount of energy that is used to collect and transport wastewater for treatment prior to safe discharge of the effluent.
- Captures the entire energy picture both upstream and downstream of an end use customer.
- Embedded energy is not associate with a particular facility but with the water itself.

Illustrative Energy Intensity Calculation for a Pump



$$EI = \frac{E}{F}$$

Embedded Energy

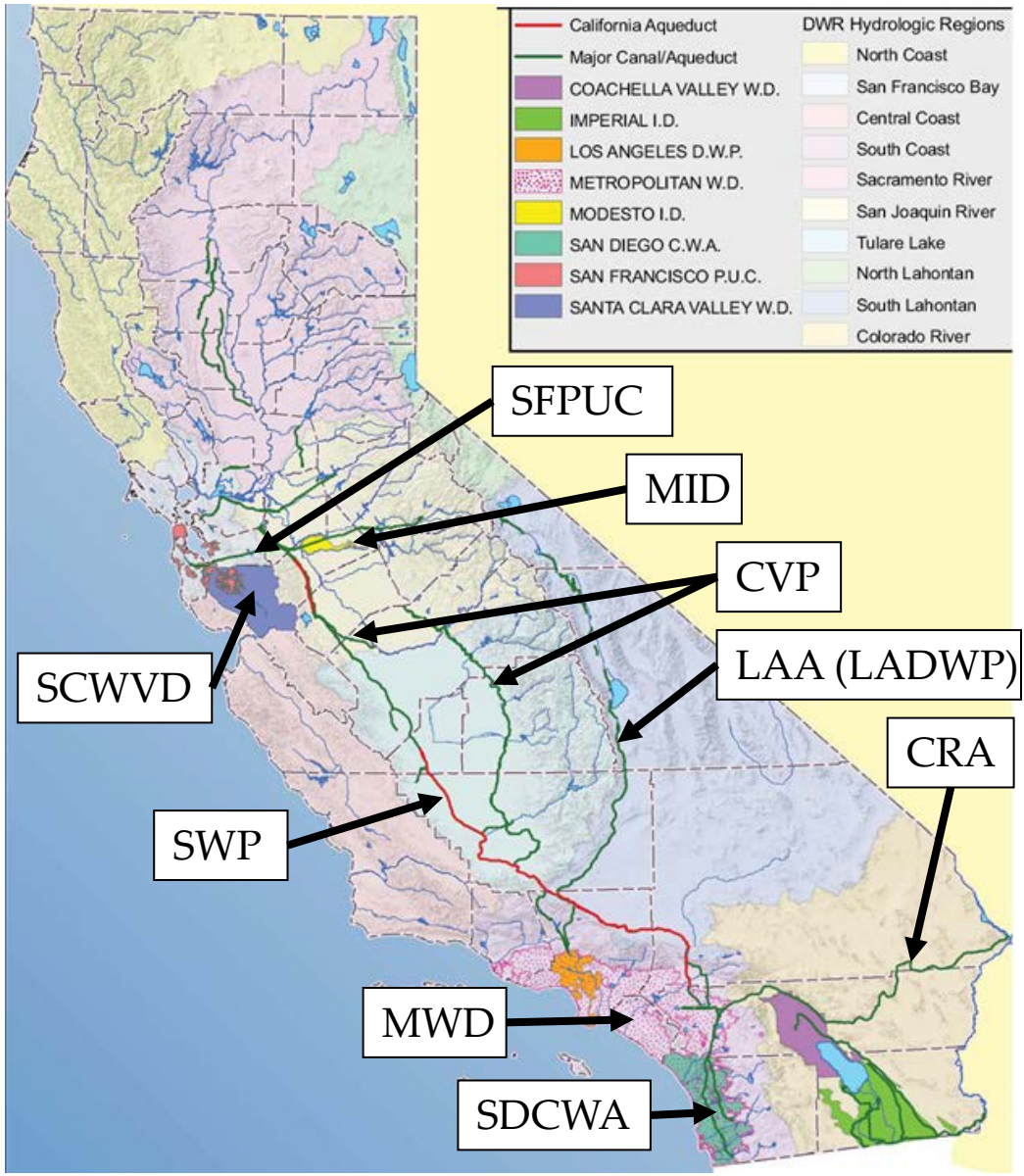


NAVIGANT ENERGY

Table of Contents

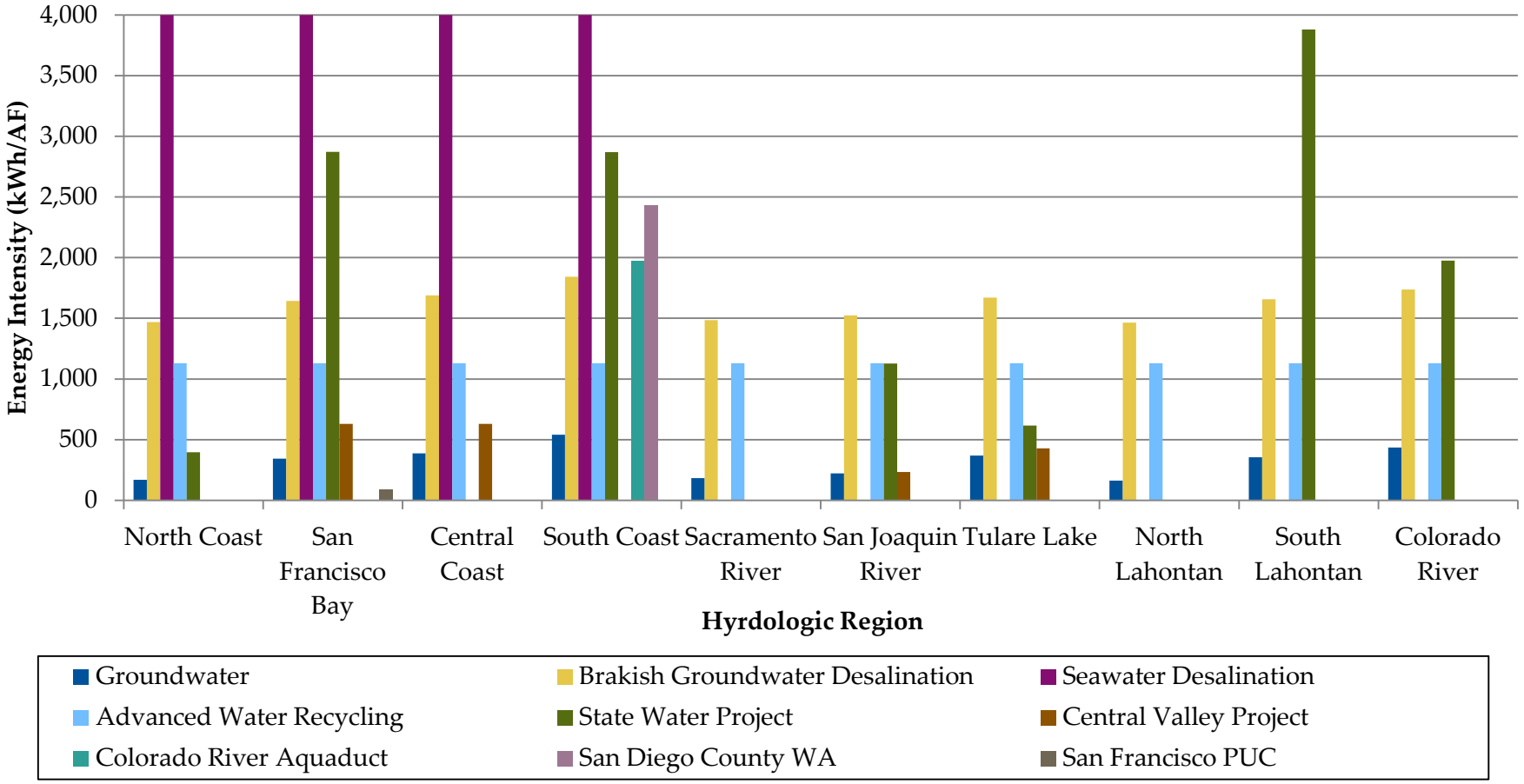
Study 1 aimed to understand and quantify the primary predictors of energy consumption related to water supply systems

- The Study Team collected 10 years of water and energy data from 9 wholesale agencies to develop a predictive model of energy use.
  - Most of these large pumping plants are powered by non-IOU energy
- Energy for water supplies not provided by the 9 agencies were added (these supplies rely more on IOU energy for operations)
  - Groundwater
  - Local Surface Water
  - Recycled Water
  - Desalination (Brackish and Seawater)



NAVIGANT ENERGY

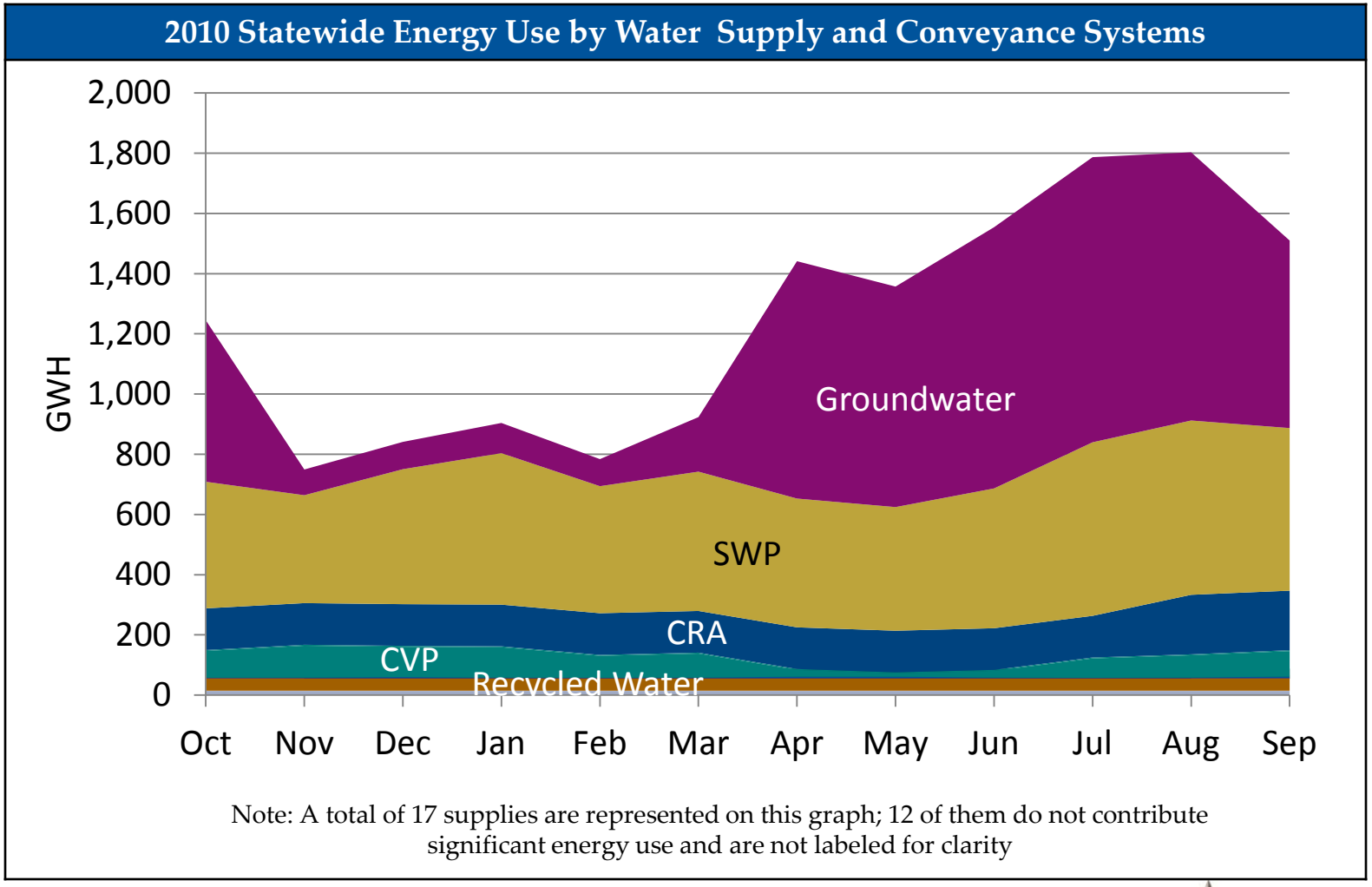
The Study Team calculated the average energy intensity of each supply to each hydrologic region as a first step to calculating total energy use.



Note: Several low intensity supplies excluded from graph for clarity: Local Surface Supply (10 kWh/AF), Los Angeles Aqueduct (0 kWh/AF)

NAVIGANT ENERGY

Statewide groundwater pumping accounts for more electricity use during summer months than pumping for the state's three largest water conveyance systems – SWP, CVP and CRA – combined.

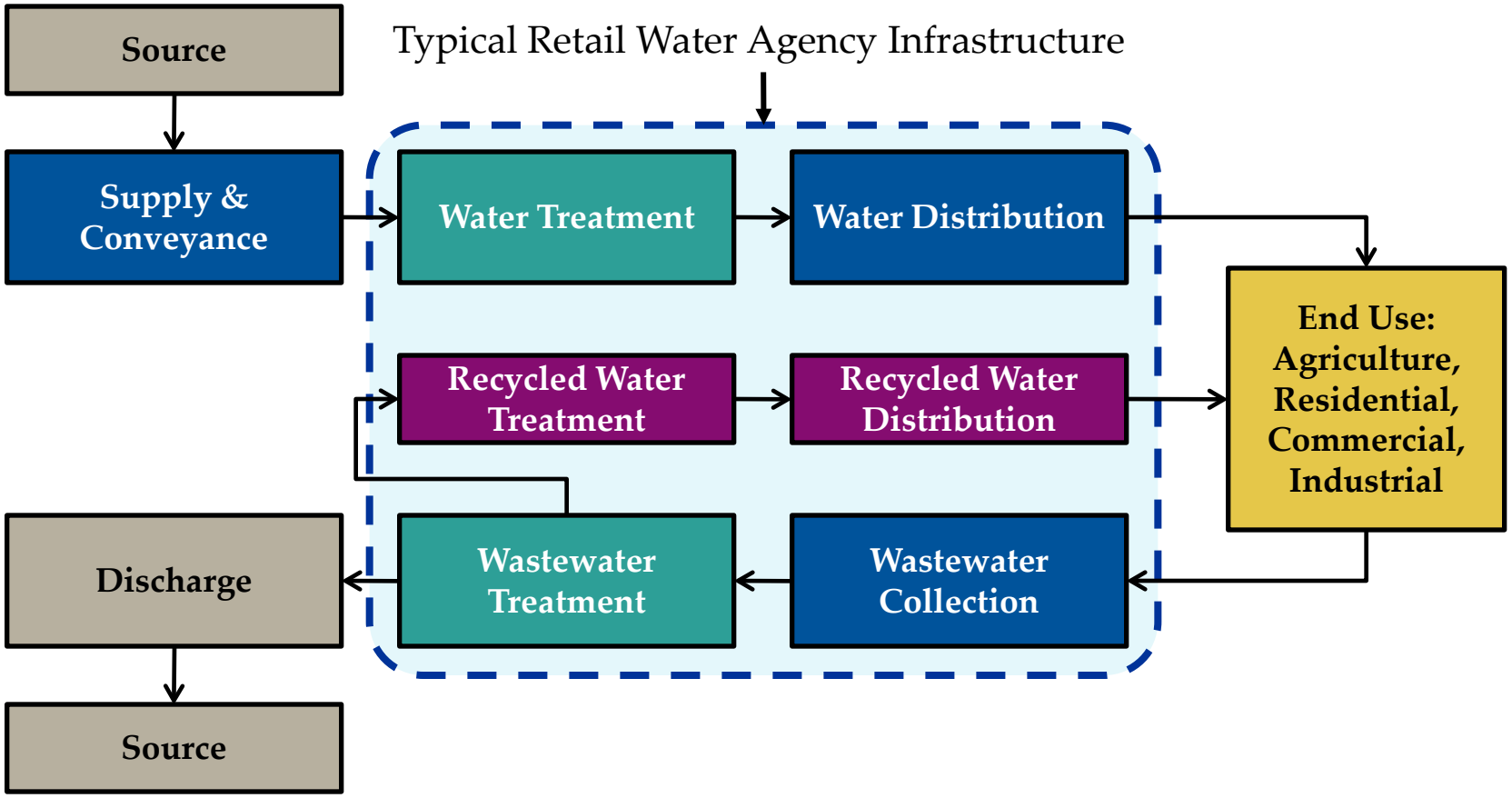


NAVIGANT ENERGY

Table of Contents

NAVIGANT ENERGY

Retail water agencies use energy in multiple end uses: groundwater pumping, treatment, distribution, wastewater treatment, and more.



NAVIGANT ENERGY

For Study 2, the team developed and refined methodologies for calculating energy intensity and embedded energy.

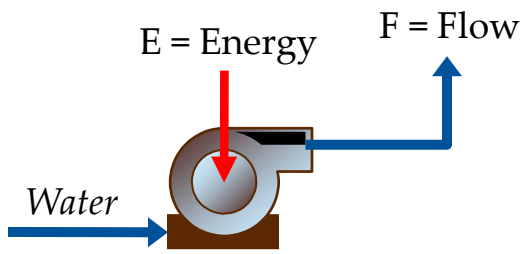
Indentify Infrastructure	Collect Energy and Water Data	Interview System Operators	Develop Analysis Algorithms	Analyze Results
» Identify various sources of water for a given agency » Understand the types of infrascture (pumps, reservoirs, canals) » Understand inter-connections	» Collect water delivery data and pump energy use data. » Link water and energy data for each piece of infrastructure	» Understand operational strategy, identify marginal supply » Address data inconsistencies	» Develop methodology to calculate system wide energy intensity » Account for multiple supplies, sources, and delivery points.	» Implement methodology in a calculation tool to process data » Examine trends and ranges of energy intensity » Produce example energy load profiles

NAVIGANT ENERGY

Varying levels of data are available for retail water utilities; lack of granularity does not prevent calculation of energy intensity.

- Energy data is often available for each facility within a water agency (sometime upwards of 100 facilities)
  - Hourly interval data – mostly for large facilities
  - Monthly energy bill data (sometimes time of use data is available)
- Water data is often only available at key points in the system (sometimes only 5-10 locations): effluent from treatment plants, production by groundwater wells
  - While water utilities may have SCADA to monitor flow rates and pressure live, though historic data is not always recorded
  - Monthly water production data is regularly recorded
  - Rarely are water flow data for individual distribution pumps available
- Study 2 saw many cases where detailed energy data was available, but water data was available only at a monthly level at a few key points
- However, this does not prevent calculation of EI…

Illustrative Energy Intensity Calculation for a Pump

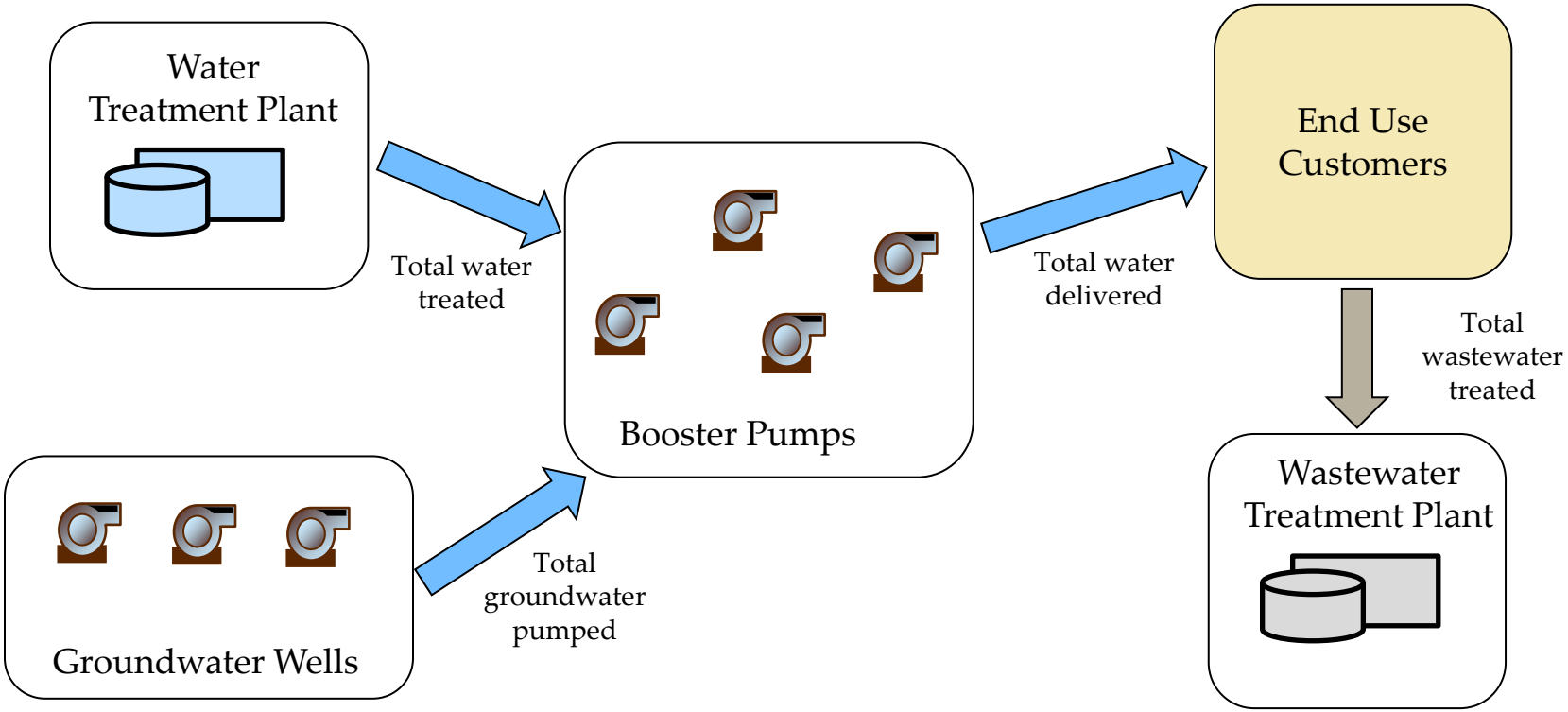


$$EI = \frac{E}{F}$$

NAVIGANT ENERGY

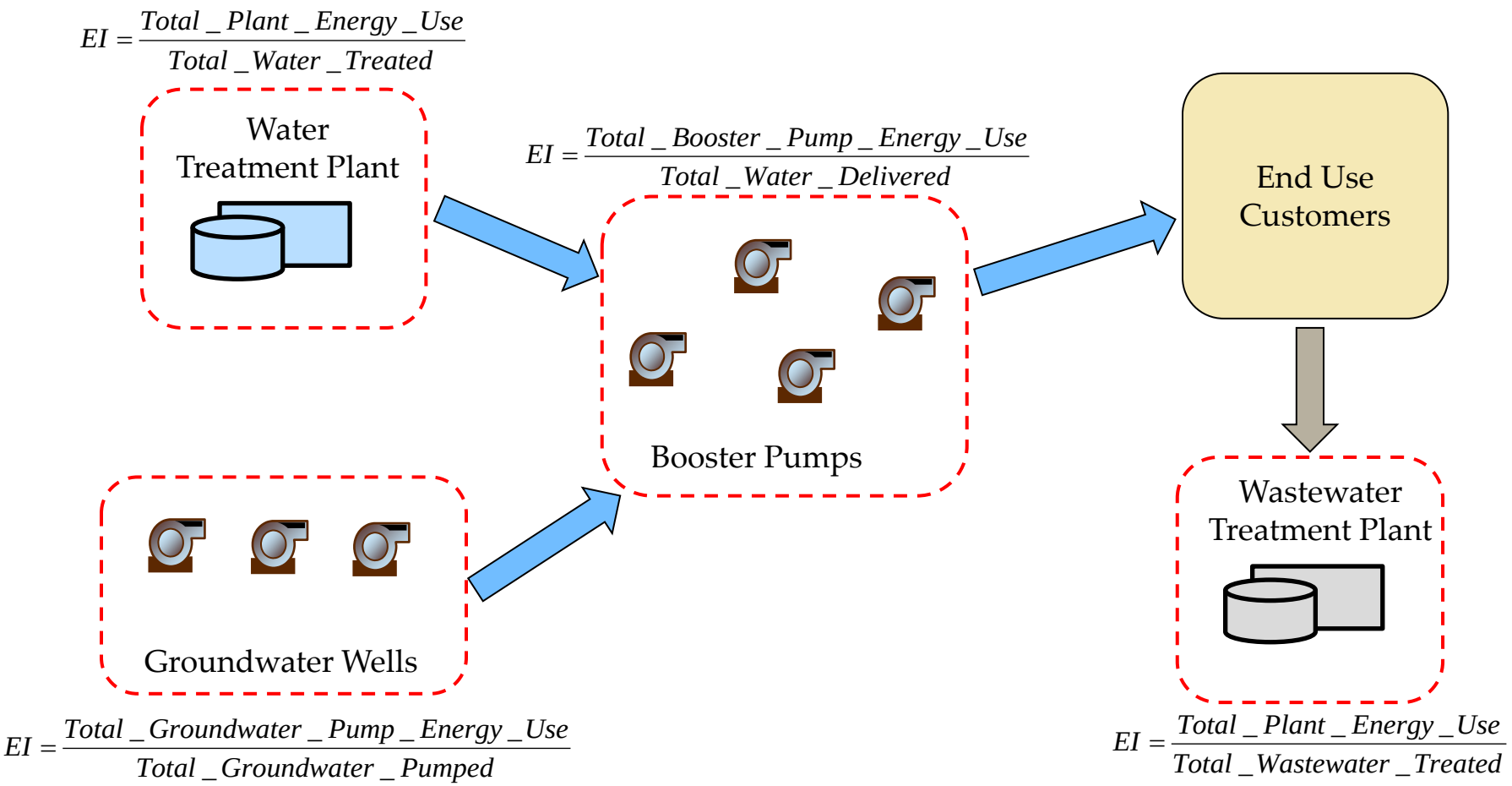
Energy intensity of water supply is calculated aggregating energy and water data for each agency.

» Energy data may be available for each individual facility, water flow data may be available only for groups of faculties



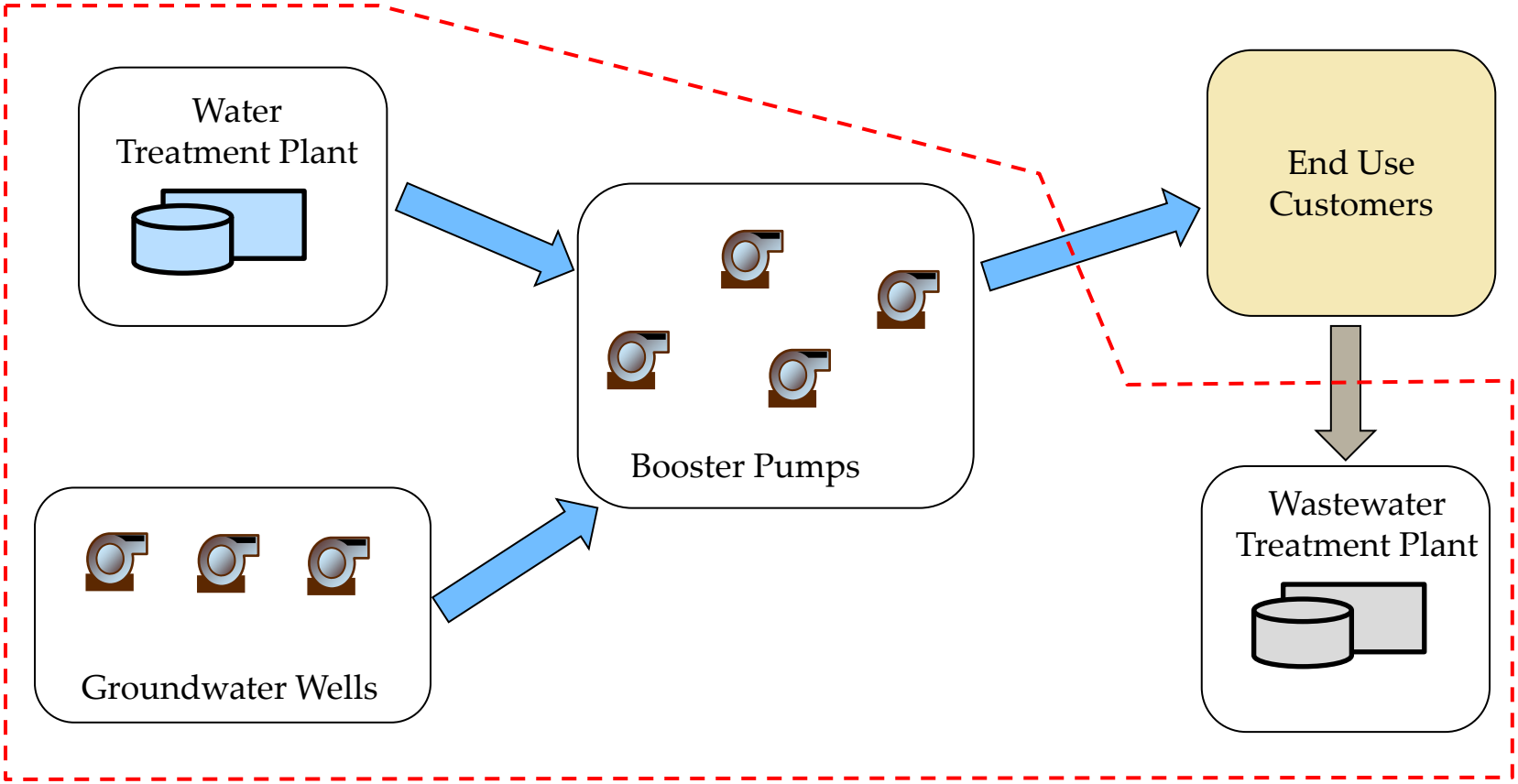
NAVIGANT ENERGY

Aggregating energy and water data for groups of facilities allows calculation of Energy Intensity by supply type.



NAVIGANT ENERGY

Aggregating energy and water data the entire agency allows calculation of average Energy Intensity of water delivered by agency.

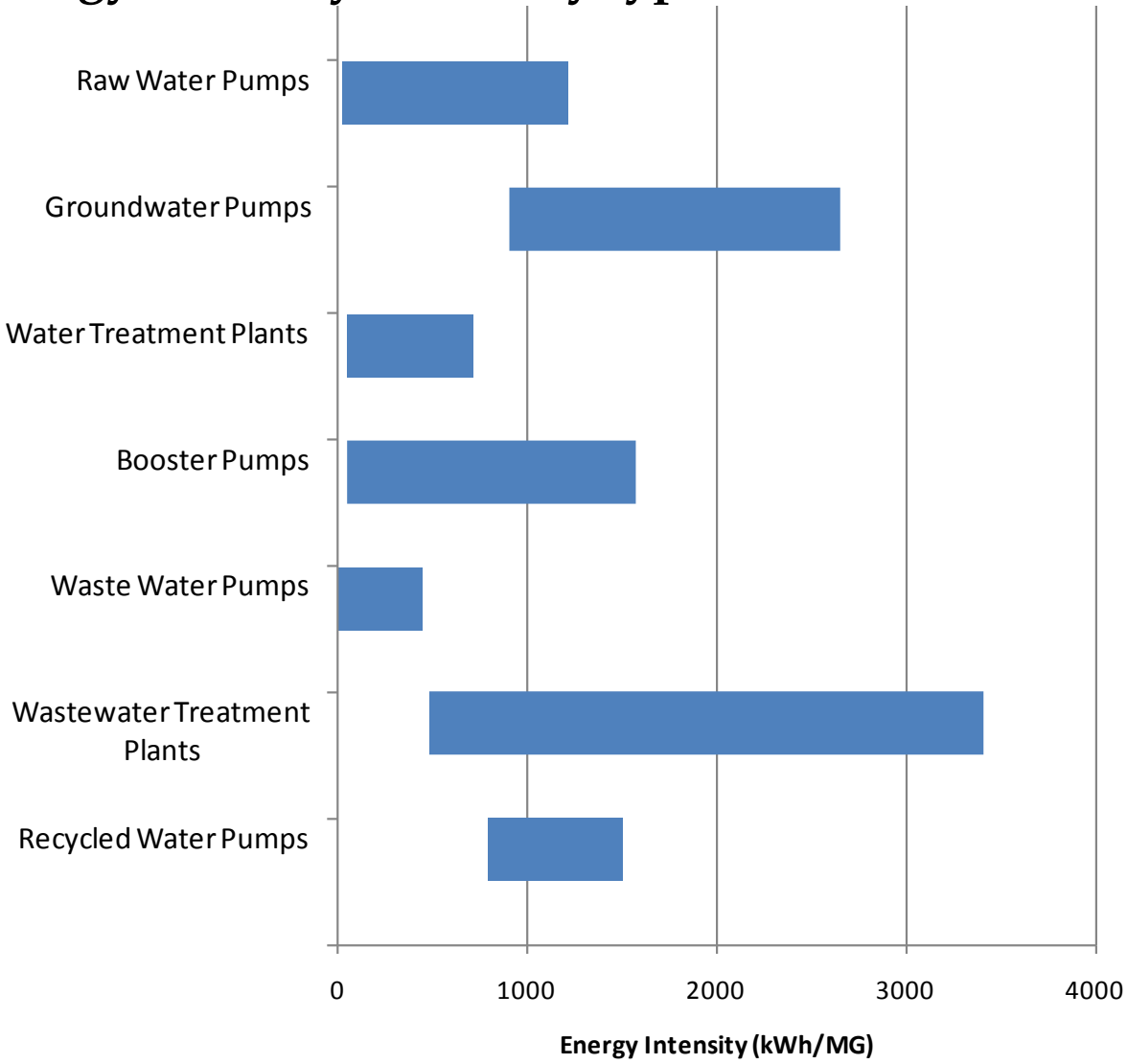


$$EI = \frac{Total\_Energy\_Use}{Total\_Water\_Delivered}$$

NAVIGANT ENERGY

Study 2 summarized the Energy Intensity of facility types statewide.

- Groundwater energy intensity depends on depth to groundwater, which varied across all agencies studied
- Distribution system energy intensity has a large range across the agencies studied. Service area size, topology and other characteristics contribute to the large range
- Water and wastewater treatment plant configurations is customized for an agency's resources, service area, and treatment requirements.



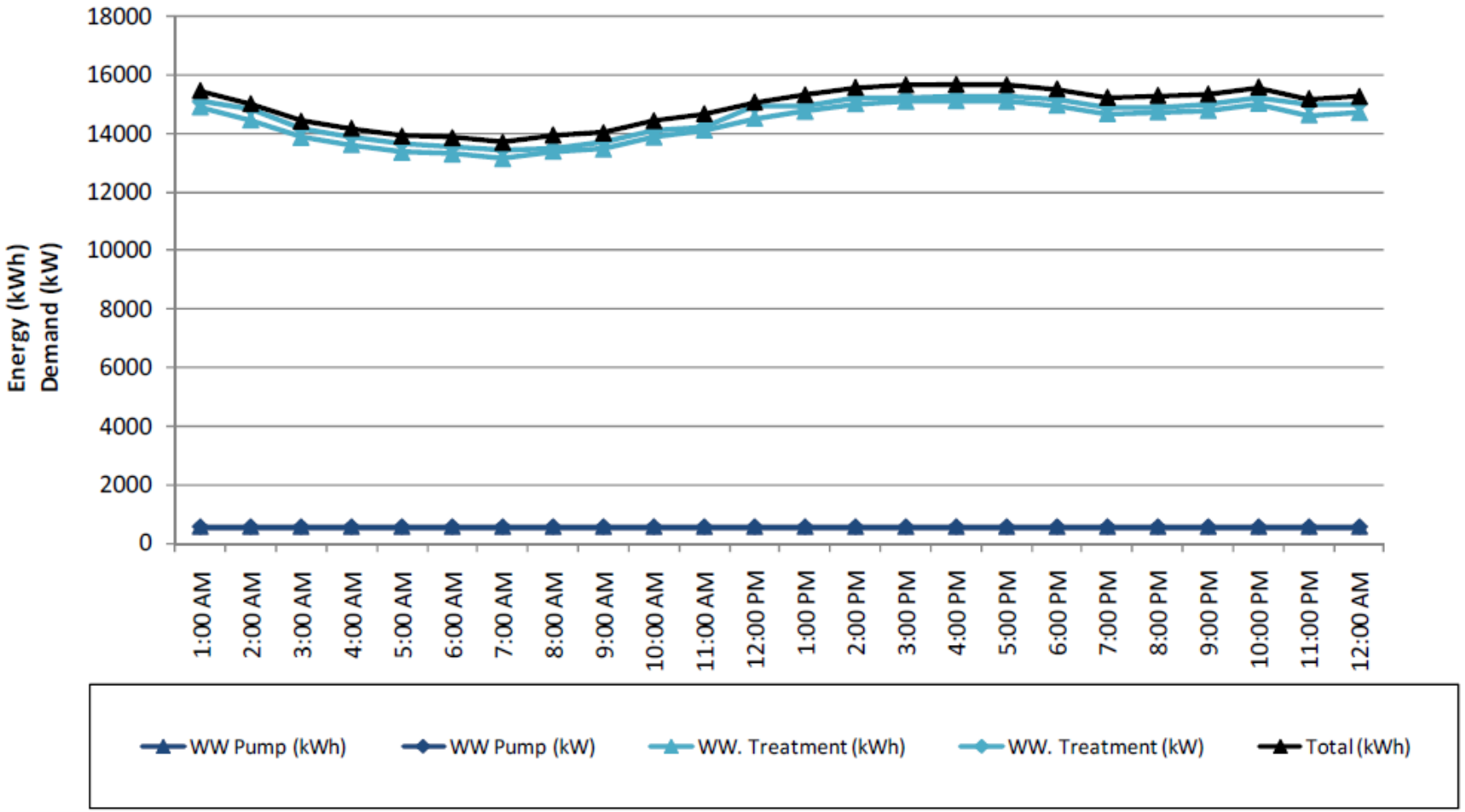
NAVIGANT ENERGY

Study 2 also examined energy load profiles to understand time-of-use of energy in the water sector.

- Variability in data granularity across agencies and facilities makes this a more challenging effort, though results are still useful
- Study 2 totaled and plotted actual energy use by each water agency by facility type (groundwater, distribution, treatment, etc.)
- Only when hourly data was available could time-of-use trends be observed
- Study 2 did not attempt to estimate the load profile of facilities for which hourly energy use was not available.
  - Pumping load profile depends on water demand, system storage capacity, service territory topology, and operation strategy
  - Monthly billed data was assumed to follow a flat load profile throughout the day
- Study 2 developed the Water Energy Load Profiling Database to store all the data from the 20+ agencies in Study 2.
  - Access database available on the CPUC website*
  - Ability to look at any of the agencies for any day in 2008
  - Detailed load profile data is available in the database
  - Instructions on use are available in Study 2: Appendix C

*http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/EM+and+V/Embedded+Energy+in+Water+Studies1_and_2.htm

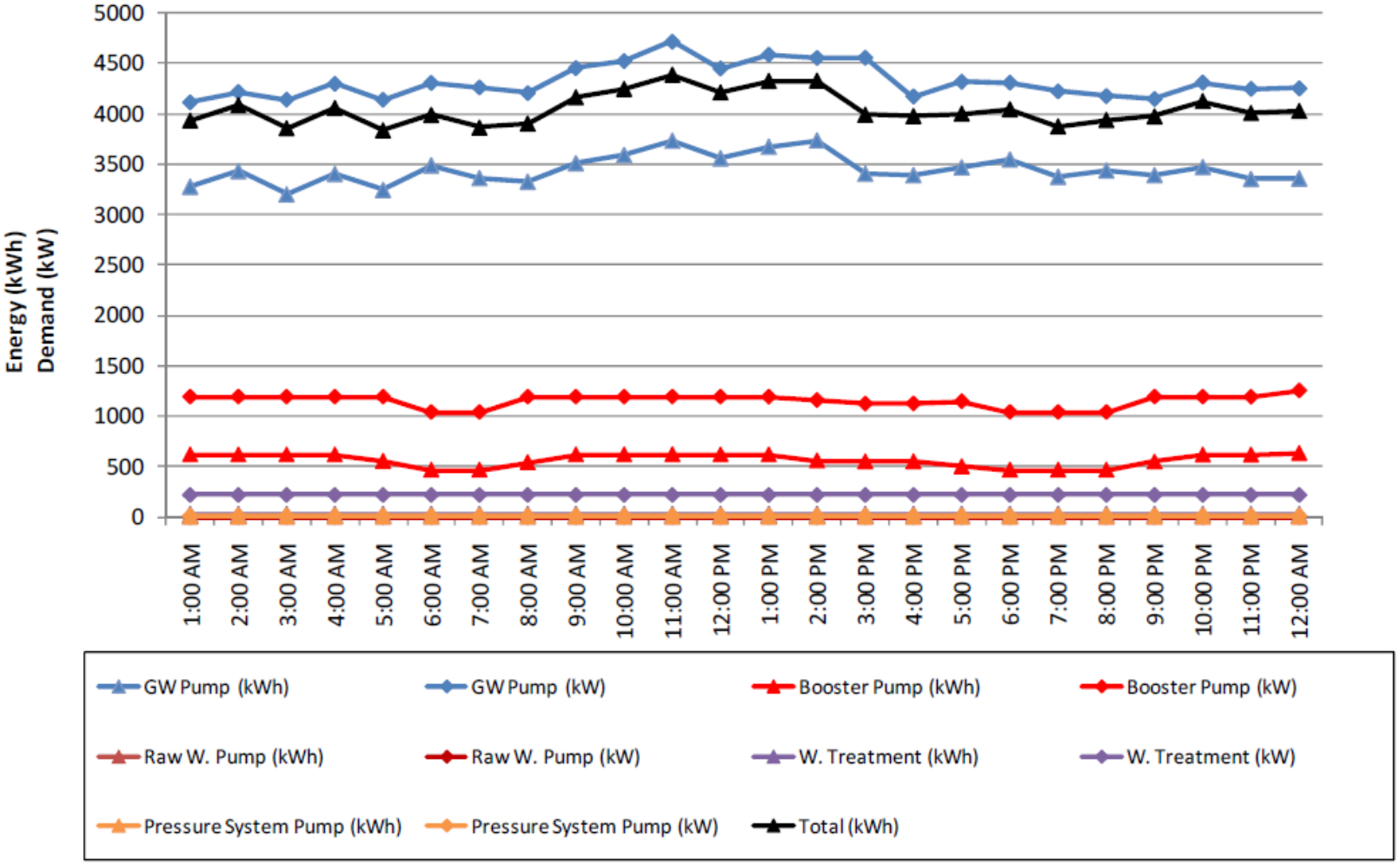
Wastewater treatment plants have a relatively consistent daily load profile: result of the consistent indoor water demand (and thus wastewater production) by customers.



Represents actual energy use by Orange County Sanitation District

NAVIGANT ENERGY

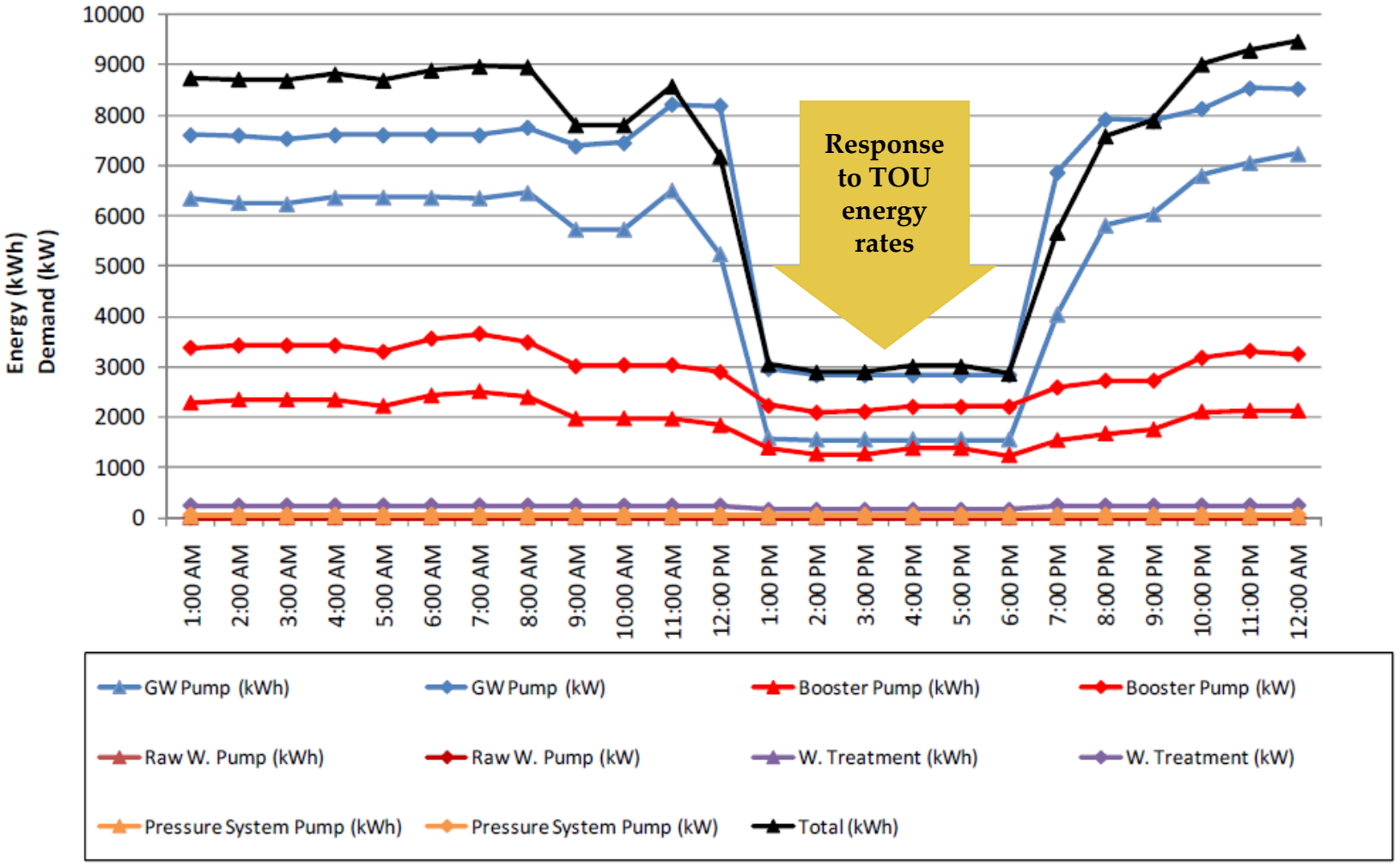
Potable distribution systems can have a relatively constant daily profile of energy use in some cases.



Represents actual energy use by San Jose Water Company

NAVIGANT ENERGY

Some potable water system operators can respond to price signals, adjust their operations and change their daily energy use profile.



Represents actual energy use by San Jose Water Company

NAVIGANT ENERGY

Study 2 and its appendices contain other types of data (some summary, some detailed) that may be useful to future water-energy work.

Water Agency Profiles: EI and Load Profiles for each Agency Studied

Contra Costa Water District (CCWD)

Summary

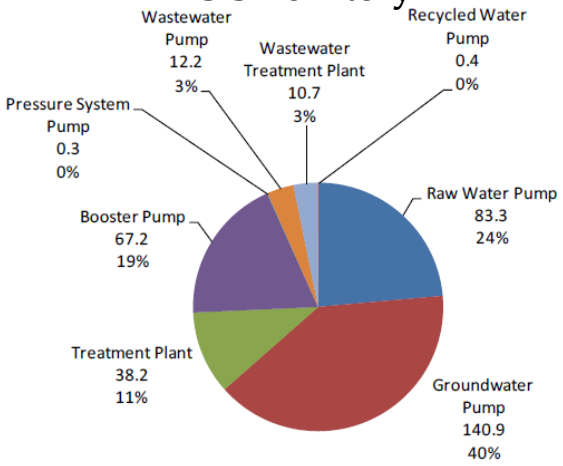
Primary functions	Urban Water, Local wholesale and retail		
Segments of Water Use Cycle	Supply, treatment, distribution		
Hydrologic Region	San Francisco and San Joaquin	DEER Climate Zone	2
Quantity of Water	Treated by Agency: 32.7 MGD (Ave for 2008) Total Distributed: 105 MGD (Ave for 2008)		
Number of Customers (2008)	Population: 550,000 Total Connections: 89,191 *Residential: 84,229* *Commercial: 3,145* *Other: 1,817*	Service Area Size	137,127 Sq miles
Distinguishing Characteristics	Contra Costa Water District's (CCWD) location in the Sacramento-San Joaquin Delta provides access to supplies from the Sacramento and San Joaquin Rivers and their tributaries. The district obtains water primarily from CVP at two locations. Water must be pumped out of the delta to reach customers at higher elevations. CCWD owns and operates Los Vaqueros Reservoir using it to control water quality and for seasonal storage.		
Key Energy Drivers	• Water Conveyance – pumping plants are required to lift water from the Delta up to the Contra Costa Canal and Los Vaqueros Reservoir at a higher elevation • Water Treatment – Two treatment plants using chlorination and ozone to treat water for CCWD customers • Water Distribution – Water is pumped to the eight-pressure zones with an elevation difference of over 450 feet		
Water Treatment Technologies	Bollman Water Treatment Plant: coagulation, flocculation, sedimentation, ozone, filtration, and disinfection Randall-Bold Water Treatment Plant: pre-ozone, coagulation, flocculation, sedimentation, filtration, post-ozone, and disinfection		
Water Resources (2005)	CVP: 82.9% Surface Water: 12.1% Groundwater: 1.4% Recycled Water: 3.6%		
Marginal Water Supplies	Short-term: CVP Water Long-term: Conservation measures, surface water transfers, regional desalination partnership, recycled water		
Energy Service Providers	PG&E, CVP, MID		

Observed Energy Intensities (kWh/Mgal)	Segment	Lower Range	Upper Range
	Raw Water Conveyance	848	1,704
	Water Treatment	895	1,210
	Water Distribution	688	1,524

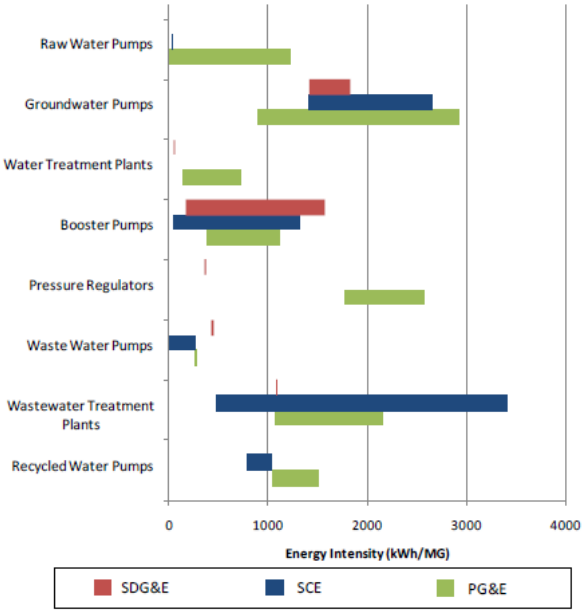
Summary EI for All Agencies Studied

Agency	Segment	Summer Average (kWh/MG)	Winter Average (kWh/MG)	Summer Range (kWh/MG)	Winter Range (kWh/MG)
Cal-Am Monterey	Groundwater	2,437	2,924	2415 - 2481	2099 - 4373
	Water Treatment	3,855	5,623	3546 - 4612	4016 - 6666
Contra Costa Water District	Booster Pumps	1,116	1,000	991 - 1352	688 – 1524
	Raw Water Pumps	1,104	1,213	934 - 1346	625 – 1704
	Water Treatment	1,080	1,039	949 - 1175	895 – 1210
East Bay Municipal Utility District (Water)	Booster Pumps	510	518	499 - 519	319 – 699
	Raw Water Pumps	355	265	10 - 1193	37 – 597
	Water Treatment	272	168	226 - 310	80 – 254
Marin Municipal Water District	Booster Pumps	379	854	352 - 412	415 - 1851
	Raw Water Pumps	399	152	341 - 480	9 - 305
	Recycled Water Pumps	1,050	1,505	969 - 1304	1076 - 1965
	Wastewater Treatment	1,072	2,165	984 - 1262	1225 - 2948
	Water Treatment	134	457	105 - 177	209 - 1045
Monterey Regional Water Pollution Control Agency	Wastewater pumps	256	275	253 - 262	243 - 333
	Wastewater Treatment	1,452	1,622	1422 - 1508	1469 - 1994
Natomas Mutual Water Company	Raw Water Pumps	5	1	2 - 12	0 - 4
San Jose Water Company	Booster Pumps	932	956	779 - 987	605 – 1219
	Groundwater	1,844	1,712	1823 - 1871	1452 – 2098
	Pressure System Pumps	1,780	2,569	1558 - 2273	2039 – 4045
	Raw Water Pumps	15	233	10 - 20	74 – 464
	Water Treatment	220	718	167 - 322	246 - 2220
Semitropic Water Storage District	Groundwater	906	1,019	790 - 1020	817 - 1261

Total Energy Use Summary by IOU Territory



Further Breakdowns of EI Ranges



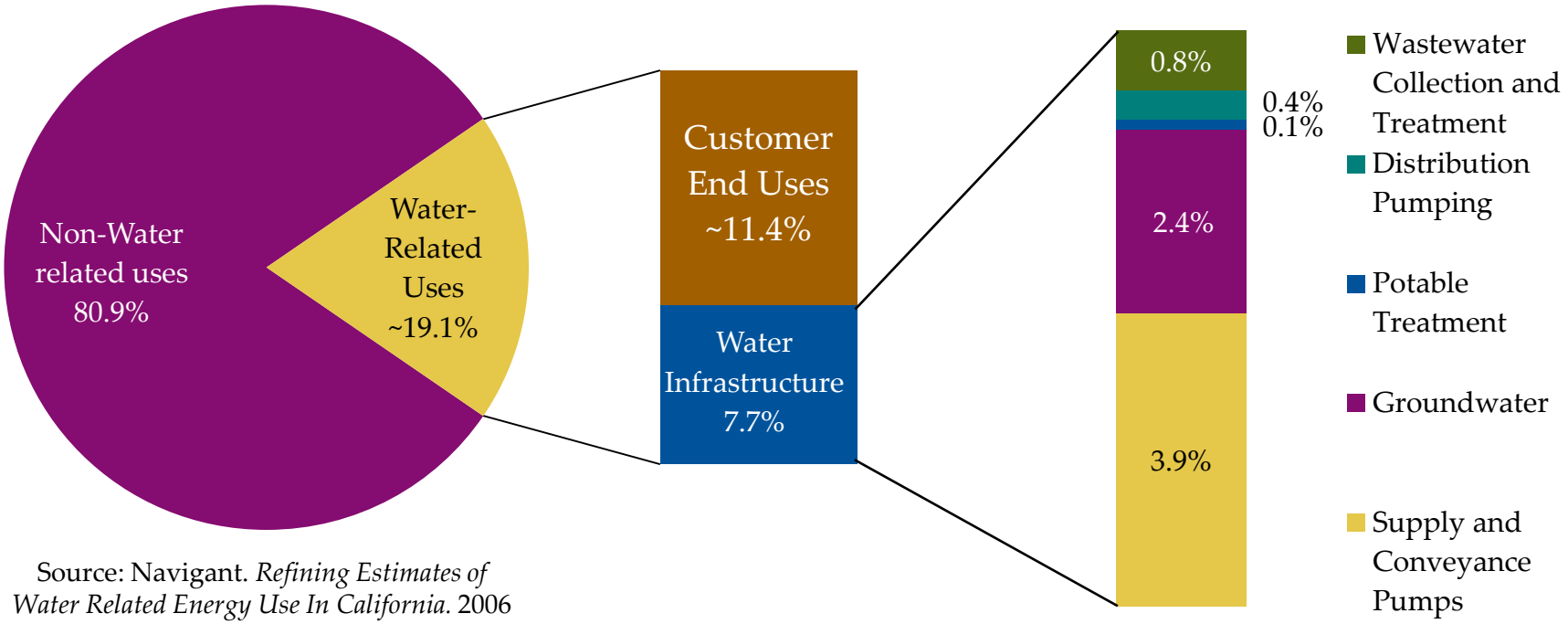
NAVIGANT ENERGY

Aggregating the data from Study 1 and Study 2 provides an updated view of the California Statewide Water-Energy Connection

» Water infrastructure in California consumes 7.7% of the state's electricity use

» Similarly, nationwide the amount is estimated to be 4%

California Statewide Electricity Use



Source: Navigant. *Refining Estimates of Water Related Energy Use In California.* 2006

Source: Study 1 and Study 2

NAVIGANT ENERGY

Key CONTACTS

NAVIGANT
ENERGY

Amul Sathe | Managing Consultant
Amul.sathe@navigant.com
415.399.2180 direct

NAVIGANT
ENERGY